A new isomer in ^{125}La

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Short note

A new isomer in ^{125}La

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Abstract

Levels in ^{125}La have been studied via β^+/EC decay of on-line mass-separated ^{125}Ce using the HIGISOL technique. A new (390 ± 40) ms isomer is definitely attributed to ^{125}La by conversion electron measurements of the 107 keV E3 isomeric transition.

Neutron deficient odd-mass La nuclei with A $\simeq$ 130 have been rather well interpreted with different theoretical models. Recently, lifetime measurements [1] of the decoupled $\pi h_{11/2}$ band levels, both in ^{127}La and ^{125}La, have reinforced the picture of a quasiparticle coupled to a rigid triaxial core ($\beta_2 \simeq 0.28$, $\gamma \simeq 20$ deg).

At first, ^{125}Ce ($T_{1/2}$ = 10 s) was identified via β-delayed proton emission [2]. Then, two γ-ray transitions were observed from its β^+/EC decay [3] and later a preliminary level scheme was reported [4]. More recently, we have suggested the existence of a (0.4 ± 0.2) s isomeric transition of 107 keV in the A=125 mass chain [5].

Therefore, the aim of the present work was to assign the Z of this isomer by means of internal conversion coefficient (ICC) measurements.

The ^{125}Ce activity was produced via the ^{94}Mo(^{36}Ar, 2p3n) reaction. The β^+/EC decay to ^{125}La was studied after mass-separation. The self-supporting 3.0 mg/cm^2 thick ^{94}Mo target enriched to 97.6%, was bombarded with 175 MeV ^{36}Ar^{8+} ions (300 part.nA) from the K = 130 Jyväskylä cyclotron. Reaction products were mass-separated using the HIGISOL technique developed originally at SARA for heavy-ion-induced fusion-evaporation reactions [6]. The system recently implemented at the Jyväskylä IGISOL facility gives readily a mass-separated yield of about 1 ion/s/mbarn/10 part.nA [7] independent of the chemical and physical properties of the elements. The 40 keV beam of A=125 radioactive ions was impinging on a 1/4 inch wide movable tape at the center of the first coil of the ELLI electron spectrometer [8]. ELLI is a hybrid design combining the features of a magnetic transporter and a high resolution with a 4 mm thick and 300 mm^2 area Si(Li) detector placed at the center of the second coil. The electron energy calibration was carried out with a ^{133}Ba source and the energy resolution was typically 2.5 keV at 320 keV. A low energy Ge detector (10 mm x 1000 mm^2) with a resolution of 530 eV at 53 keV, was placed outside the vacuum chamber, on the symmetry axis of the spectrometer and only 10 mm from the implantation spot.

To provide growth and decay sequences of the activities, the cyclotron beam was pulsed (T_{ON}=T_{OFF}=10 s) and the implantation tape was moved in the end of the beam OFF period. Both time-sequenced singles spectra (e-T, γ-T) and e-γ-t coincidence data were acquired and stored on an exabyte tape using the VENLA data acquisition system [9]. T was the time of occurrence of an event with respect to the beginning of the acquisition cycle whereas t was the time between electrons (e) and γ signals.

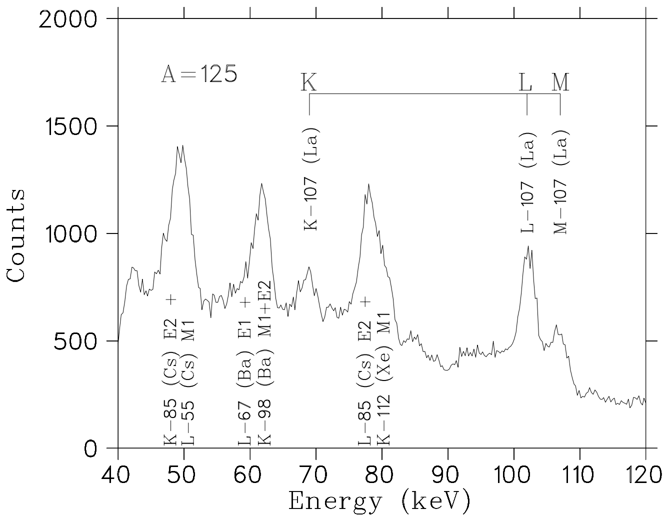

Figure 1: Partial conversion electron spectrum measured with the ELLI spectrometer.

Figure 1 shows the conversion electron spectrum measured with the ELLI spectrometer. Three e-lines at 68.2, 101.7 and 106.2 keV are new. The energy differences between these electron lines are (33.5±0.3) and (4.5±0.3) keV in perfect agreement with the well known values of 33.24 and 4.53 keV for the K-L and L-M differences of La. Moreover, in e-γ data there is clear evidence of a coincidence between 68.1 keV electrons and both K_α - and K_β - La X rays corroborating that conversion takes place in the element La.

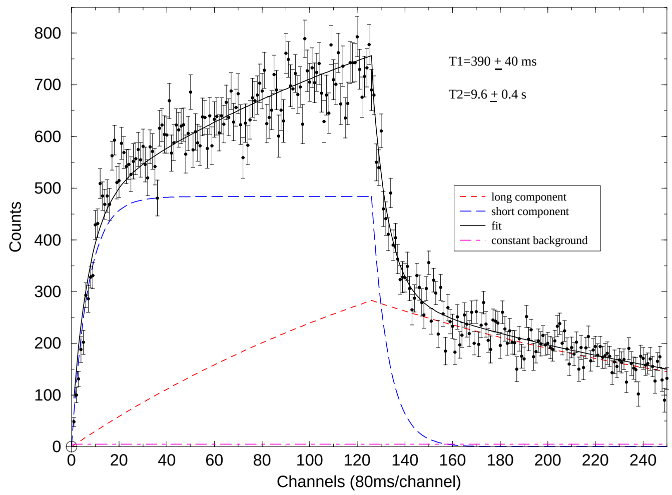

Figure 2: Growth and decay of singles K+L+M electrons of the 107.0 keV E3 transition. The curve is fitted by assuming two components and long lived (constant) contamination.

Table 1 shows the deduced ICC values and their ratios for the 107 keV transition. Comparing with theoretical values calculated in reference [10] and [11], the E3 nature can be assigned unambiguously to this transition.

From the e-T data, we could extract the time distributions (growth and decay) for the K-, L- and M-lines of the 107 keV transition. They exhibit a similar time behaviour with the presence of two components (fig. 2).
Growth and decay have been analysed considering feeding of the isomer via the ^{125}Ce β^+/EC decay and via direct production in the nuclear reaction. For the slow component the obtained half-life value $T_{1/2} = (9.6 \pm 0.4)$ s is in good agreement with the previous results [2] for the ^{125}Ce decay. The short component with $T_{1/2} = (390 \pm 40)$ ms is assigned to the isomeric decay of ^{125}La, corroborating the result we got from K_α-La X ray analysis [5]. Assuming that the 107 keV transition is of E3 nature, the hindrance factor derived from the ratio of experimental half-life to its Weisskopf estimate is F_W=1.3±0.2, and this indicates the single particle character of the states involved. This value is very close to those measured in the neighbouring nuclei ^{129}La and ^{123}Ce.

It is worth noting that there are no common transitions with those observed in beam [1]. According to the fit of figure 2, the isomeric level is fed by about 60% via the β^+/EC decay of ^{125}Ce. Since the ground state of ^{125}Ce has been assigned with I^π=$(5/2^+)$ [2], this suggests low-spin and even parity for the isomer in ^{125}La. Alternatively, we might have a $7/2^-$ or $7/2^+$ isomer in ^{125}Ce (as in ^{127}Ce or ^{129}Ba) which β-decays to a high spin level (9/2 or 11/2) in ^{125}La. Still more detailed data are required to infer the low-lying level structure of ^{125}La.

Table 1: γ ray and internal conversion electron data for the 107.0 keV transition in ^{125}La. Theoretical values were obtained from ref [10]. The total M-shell value includes N- and O- shell conversion values in ref [11].

$E_\gamma(\Delta E_\gamma)$ (keV)	Electron line	ICC and ratios	Experiment	Theory E2	E3	E4	M1	M2	M3
107.0 (.1)	K	α_K	2.5 ± 1.5	1.0	4.8	22	0.80	6.5	42
	L	α_L	8.1 ± 3.2	0.47	10.9	189	0.10	1.48	20.8
	M	α_M	2.4 ± 1.0	0.15	3.5	74	0.024	0.35	6.5
		L/K	3.2 ± 0.7	0.47	2.27	8.6	0.125	0.227	0.495
		M/K	1.0 ± 0.7	0.15	0.729	3.36	0.030	0.054	0.155

Aknowlegments

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